DECLARATION

I, Kazuo ISHII of 9-14, Nasuzukuri 4-chome, Hirakata-shi, Osaka,573-0071 Japan hereby declare that I am conversant with the Japanese language and that I am the translator of the document attached and certify that to the best of my knowledge and belief the following is a true and correct English translation of the specification contained in the Priority Document No. JP 2002-230538.

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[DOCUMENT NAME] Specification

[TITLE OF THE INVENTION] Fuel cell

[CLAIMS]

[Claim 1] A fuel cell comprising: a polymer electrolyte membrane; a pair of electrodes sandwiching said polymer electrolyte membrane; and a pair of separator plates disposed outside said electrodes and having a gas flow channel for supplying a fuel gas or an oxidant gas to said electrodes, wherein each of said electrodes comprises a catalyst layer and a gas diffusion layer, and said gas diffusion layer protrudes into the gas flow channel of the adjacent separator plate by 0.10 to 0.25 mm.

[Claim 2] The fuel cell in accordance with claim 1, wherein the gas flow channel of each of said separator plates has a width of 1.0 to 2.0 mm and a depth of 1.0 to 2.0 mm, and a rib formed between the gas flow channels has a width of 0.5 to 1.0 mm.

[DETAILED DESCRIPTION OF THE INVENTION]

[0001]

[Technical Field to Which the Invention Belongs]

The present invention relates to a fuel cell that uses pure hydrogen or hydrogen reformed from methanol or fossil fuels as a fuel, or that directly uses liquid fuel such

as methanol, ethanol or dimethyl ether, together with air or oxygen as an oxidant. The present invention particularly pertains to a fuel cell using a solid polymer electrolyte.

[0002]

[Prior Art]

A conventional electrode for polymer electrolyte fuel cells is composed of a catalyst layer which comes in contact with a polymer electrolyte membrane and a gas diffusion layer provided on the outer surface of the catalyst layer. The gas diffusion layer has three major functions. The first one is a function of diffusing a reaction gas for evenly supplying the reaction gas, such as a fuel gas or an oxidant gas, to the catalyst of the catalyst layer from a gas flow channel formed on the outer side of the gas diffusion layer. The second is a function of promptly discharging water produced by the reaction at the catalyst layer into the gas flow channel. The third is a function of conducting electrons required or generated by the reaction. Therefore, high reaction gas permeability, water permeability and electronic conductivity become necessary. As the conventional techniques, the followings have been conducted: the gas diffusion layer has a porous structure in order to obtain the gas permeability; a water-repellent polymer, such as fluorocarbon resin, is dispersed in the gas diffusion layer for suppressing water clogging (flooding), in order to obtain the water permeability; and the gas diffusion layer is made of an

electron conductive material, such as carbon fiber, metal fiber or carbon fine powder, in order to obtain the electronic conductivity.

[0003]

[Problem That the Invention Is to Solve]

As a material having the above-described three functions, carbon paper is conventionally used for the gas diffusion layer. However, a fuel cell using carbon paper for the gas diffusion layer causes a voltage drop due to flooding when the relative humidities of the fuel gas and the oxidant gas become 98% or higher, so that stable operation becomes impossible. This is caused by the following reason. Due to the high gas diffusibility of carbon paper, the proportion of an underflow, which is a flow of the reaction gas under the rib formed between the gas flow channels of a separator plate, increases, so that the pressure loss of the reaction gas is reduced, thereby impairing the water permeability. Thus, if the flow rate of the reaction gas is increased to heighten the pressure loss of the reaction gas, stable operation becomes possible. However, this also causes a decrease in efficiency of the fuel cell.

[0004]

A fuel cell using carbon nonwoven fabric for the gas diffusion layer is capable of stable operation even when the relative humidities of the fuel gas and the oxidant gas are 98% or higher. However, the voltage decreases in comparison

with that of the fuel cell using carbon paper. The reason of high resistance to flooding even at high degrees of humidification of the supplied gases is that the clamping pressure of the assembled fuel cell compresses the carbon nonwoven fabric as a whole, so that the gas permeability of the carbon nonwoven fabric is lowered, resulting in a decreased proportion of the underflow and a high pressure loss. However, the lowered gas permeability also causes a decrease in discharge performance of the fuel cell.

[0005]

The present invention solves the above-described conventional problems and aims to provide an electrode for fuel cells which ensures gas diffusibility and excessive water permeability of a gas diffusion layer.

The present invention aims to provide a fuel cell having high discharge performance and stability particularly in power generation under highly humidified conditions, by reducing the proportion of an underflow while ensuring the porosity of the gas diffusion layer necessary for gas diffusion.

[0006]

[Means for Solving the Problem]

In order to solve the above-described problems, a fuel cell in accordance with the present invention includes: a polymer electrolyte membrane; a pair of electrodes sandwiching the polymer electrolyte membrane; and a pair of separator

plates disposed outside the electrodes and having a gas flow channel for supplying a fuel gas or an oxidant gas to the electrodes. It is characterized in that each of the electrodes comprises a catalyst layer and a gas diffusion layer, and the gas diffusion layer protrudes into the gas flow channel of the adjacent separator plate by 0.10 to 0.25 mm.
[0007]

In the fuel cell of the present invention, while the porosity of the gas diffusion layer that faces the gas flow channel is ensured, the porosity is decreased at the portion that comes in contact with the rib formed between the gas flow channels, for example, by a method of compressing the gas diffusion layer. This lowers the gas diffusibility and reduces the proportion of the underflow. Accordingly, it is possible to provide a fuel cell having excellent cell performance and stability.
[0008]

[Mode for Embodying the Invention]

The fuel cell of the present invention is characterized in that the gas diffusion layer of the electrode protrudes into or becomes swollen toward the gas flow channel of the adjacent separator plate by 0.10 mm or more and 0.25 mm or less. This makes it possible to lower the gas permeability of the portion of the gas diffusion layer to come in contact with the rib formed between the gas flow channels, while retaining the porosity of the gas diffusion layer facing the

gas flow channel.

[0009]

In the case where the gas diffusion layer protrudes into the gas flow channel, if the cross-sectional area of the gas flow channel is extremely small, the pressure loss of the reaction gas increases sharply, thereby posing a problem regarding the strength of the materials constituting the fuel cell. On the other hand, this decreases the proportion of the underflow, so that the electrode reaction is hindered at the portion contacting the rib of the separator plate, resulting in a decrease in cell performance. From the above, in the case where the gas diffusion layer protrudes into the gas flow channel, the gas flow channel needs to have a cross-sectional area larger than a certain level, and the width of the rib is desirably narrower.

From the above viewpoints, regarding the shape of the gas flow channel of the separator plate, it is preferable that the gas flow channel have a width of not less than 1.0 mm and not more than 2.0 mm, a depth of not less than 1.0 mm and not more than 2.0 mm, and a rib width of not less than 0.5 mm and not more than 1.0 mm. Such dimensions of the gas flow channel can eliminate the adverse effects of the change in cross-sectional area of the gas flow channel and the decrease in reaction area under the rib, caused by the protrusion of the gas diffusion layer into the gas flow channel.

[0010]

In the following, embodiments of the present invention will be described.

FIG. 1 illustrates the structure of the main part of a conventional polymer electrolyte fuel cell. Numeral 1 represents a polymer electrolyte membrane 1. Catalyst layers 2A and 2B are disposed on the outer surfaces of the polymer electrolyte membrane 1, and gas diffusion layers 3A and 3B are disposed on the outer surfaces thereof. Outside them are separator plates 4A and 4B. The separator plates 4A and 4B have gas flow channels 5A and 5B, respectively. 6A and 6B are ribs formed between the gas flow channels.

The electrode reaction takes place at the catalyst surfaces of the catalyst layers 2A and 2B. For example, an anode reaction gas is supplied to the catalyst layer 2A though the gas diffusion layer 3A from the gas flow channel 5A of the separator plate 4A, while a cathode reaction gas is supplied to the catalyst layer 2B though the gas diffusion layer 3B from the gas flow channel 5B of the separator plate 4B. The reaction $H_2 \rightarrow 2H^+ + 2e^-$ takes place at the anode catalyst layer 2A, while the reaction $1/2O_2 + 2H^+ + 2e^- \rightarrow H_2O$ takes place at the cathode catalyst layer 2B. The total reaction is $H_2 + 1/2O_2 \rightarrow H_2O + Q$. This reaction produces electromotive force, and its electrical energy generates electric power. Simultaneously, water is generated at the cathode catalyst layer 2B. In the electromotive reaction, H^+ ions generated at the anode catalyst layer 2A move through the polymer

electrolyte membrane 1 to the cathode catalyst layer 2B.

[0011]

In the movement of the H^+ ions, one H^+ ion is accompanied by 5 to 20 H_2O molecules. The polymer electrolyte membrane has a property of exhibiting high H^+ ion conductivity only in the presence of sufficient water. Hence, water is also transferred with the H^+ ions moving through the polymer electrolyte membrane, and it is thus necessary to constantly supply water to avoid shortage of water. Water is supplied in the form of steam to the polymer electrolyte membrane through the gas flow channels 5A and 5B and the gas diffusion layers 3A and 3B from inlet-side manifold apertures, for the reaction gases, of the separator plates. Of the water produced in the cathode catalyst layer, excessive water that is not necessary for the polymer electrolyte membrane is discharged from outlet-side manifold apertures through the gas diffusion layers 3A and 3B and the gas flow channels 5A and 5B of the separator plates.

[0012]

As described above, it is important for the fuel cell to ensure the gas diffusibility and the excessive-water discharging capability of the gas diffusion layers 3A and 3B which water frequently goes in and out, and it is also necessary, in terms of the long-term reliability, to design such that the excessive water can be promptly discharged. The excessive water is pushed out or transferred through the gas

flow channels 5A and 5B and the gas diffusion layers 3A and 3B by the reaction gases. Thus, the pressure losses of the reaction gases need to be maintained at high level in order to enhance the excessive-water discharging capability. However, when the gas diffusion layers have high gas permeability at their portions contacting the ribs 6A and 6B between the gas flow channels, the proportion of the underflow, which is a flow of the gas passing under the ribs, increases as illustrated in FIG. 2, causing a decrease in pressure loss of the reaction gas.

[0013]

FIG. 2 is a front view of an anode-side separator plate 14. An anode is located at a section surrounded by a dash-dotted line 13. A fuel gas supplied from a fuel gas inlet-side manifold aperture 10a passes through a gas flow channel 15, which connects the manifold aperture 10a to an outlet-side manifold aperture 10b, and is discharged from the manifold aperture 10b. Arrows 16 of this figure show the flow of the gas passing through the flow channel 15, while arrows 17 show the underflow through the gas diffusion layer of the electrode in contact with the separator plate. In the figure, the gas flow channel is composed of one groove, but it may be composed of a plurality of parallel grooves. 11a and 11b are an inlet-side manifold aperture and an outlet-side manifold aperture, respectively, for an oxidant gas, and 12a and 12b are an inlet-side manifold aperture and an outlet-side

manifold aperture, respectively, for cooling water.

[0014]

According to the present invention, the gas diffusion layer contacting the rib formed between the gas flow channels of the separator plate is compressed to lower the gas diffusibility and reduce the proportion of the underflow of the reaction gas, and at the same time, the portion of the gas diffusion layer facing the gas flow channel is allowed to protrude into the gas flow channel to maintain the porosity thereof at high level and avoid the deterioration of the gas diffusibility. In this way, by discharging the excessive water in the electrode, it is possible to provide a fuel cell having high discharge characteristics and reliability which is free from water clogging, flooding, and deterioration of gas diffusibility of the electrode. As described above, the use of the gas diffusion layer of the present invention makes it possible to provide a fuel cell having high discharge characteristics and reliability.

In the following, embodiments of the present invention will be described in detail with reference to drawings.

[0015]

Embodiment 1

FIG. 3 is a sectional view of the main part of a unit cell in this embodiment. 24A represents an anode-side separator plate having a gas flow channel 25A, which is

composed of a groove, on its anode-facing side. Likewise, 24B represents a cathode-side separator plate having a gas flow channel 25B on its cathode-facing side. The gas flow channels 25A and 25B of these separator plates 24A and 24B are disposed at opposing positions except for an unavoidable portion. Ribs 26A and 26B are formed between the gas flow channels 25A and between the gas flow channels 25B, respectively.

An electrolyte membrane electrode assembly (MEA) sandwiched between these two separator plates comprises a polymer electrolyte membrane 21 and a pair of electrodes, i.e., an anode and a cathode, sandwiching the polymer electrolyte membrane. Each of the electrodes comprises a catalyst layer which comes in contact with the polymer electrolyte membrane and a gas diffusion layer provided on the outer surface of the catalyst layer. In the following figures, the electrode is illustrated as one layer, and electrode compression and protrusion is mainly only the gas diffusion layer.

[0016]

By appropriately setting the width and depth of the gas flow channel of the separator plate and the width of the rib between the flow channels and by adjusting the clamping pressure of the cell, electrode portions 22A and 22B of the gas diffusion layers facing the gas flow channels can be allowed to protrude into the gas flow channels 25A and 25B, and at the same time, electrode portions 22A and 22B of the gas diffusion layers sandwiched by the ribs 26A and 26B can be

compressed.

According to this structure, the portion of the gas diffusion layer facing the gas flow channel can retain good gas diffusibility and water permeability, and moreover, the underflow of the gas can be reduced.

[0017]

Embodiment 2

FIG. 4 is a sectional view of the main part of a gas diffusion layer in this embodiment, and FIG. 5 is a sectional view of a unit cell using the same gas diffusion layer.

Carbon nonwoven fabric serving as a gas diffusion layer is pressed in advance by a corresponding separator plate to form an uncompressed portion 31 having a shape corresponding to that of the gas flow channel and a compressed portion 32. A recess 33 is formed in the compressed portion 32. An MEA incorporating such gas diffusion layers is sandwiched by separator plates to assemble a unit cell such that the ribs of the separator plates are fitted into the recesses 33 of the compressed portions 32 of the gas diffusion layers.

[0018]

FIG. 5 illustrates such a unit cell. A polymer electrolyte membrane 41 is sandwiched by a pair of electrodes, i.e., an anode and a cathode. Each of the electrodes has a catalyst layer on the side opposite to the surface having the recess 33 of the gas diffusion layer. On the anode side, a

compressed portion 43A of the gas diffusion layer is in contact with a rib 46A of a separator plate 44A, and an uncompressed portion 42A of the gas diffusion layer become swollen toward a gas flow channel 45A. Likewise, on the cathode side, a compressed portion 43B of the gas diffusion layer is in contact with a rib 46B of a separator plate 44B, and an uncompressed portion 42B of the gas diffusion layer become swollen toward a gas flow channel 45B.

[0019]

The foregoing embodiments have described a unit cell comprising an MEA sandwiched by an anode-side separator plate and a cathode-side separator plate. A cell stack of a plurality of unit cells is normally used in a fuel cell. In such a cell stack, a separator plate having a fuel gas flow channel on one side and an oxidant gas flow channel on the other side, which serves both as an anode-side separator plate and a cathode-side separator plate, is inserted between the MEAs. Also, a cooling section is provided every one to three cells. The cooling section is formed by a composite separator plate consisting of an anode-side separator plate and a cathode-side separator plate each having a cooling water flow channel on the backside, the separator plates being joined together such that their cooling water flow channels face each other.

[0020]

[Working Examples]

In the following, examples will be described.

<<Example 1>>

First, a method of producing an electrode having a catalyst layer will be explained.

An electrode catalyst was prepared by placing 25% by weight of platinum particles having an average particle size of approximately 30 Å on an acetylene black powder. A dispersion of this catalyst powder in isopropanol was mixed with a dispersion of perfluorocarbon sulfonic acid powder in ethyl alcohol to form a catalyst paste.

Meanwhile, carbon nonwoven fabric having an external size of 16 cm × 16 cm and a thickness of 0.36 mm (TGP-H-120 manufactured by Toray Industries, Inc.) was impregnated with an aqueous dispersion of fluorocarbon resin (NEOFLON ND1 manufactured by Daikin Industries, Ltd.), dried, and heated at 400℃ for 30 minutes in order to make it water-repellent. The catalyst paste was applied by screen printing onto one side of the carbon nonwoven fabric to form a catalyst layer. The catalyst layer was partially embedded in the carbon nonwoven fabric. In this way, a pair of electrodes each comprising the catalyst layer and the carbon nonwoven fabric were prepared. In each of the electrodes, the content of platinum was 0.5 mg/cm^2, and the content of perfluorocarbon sulfonic acid was 1.2 mg/cm^2.

[0021]

Subsequently, the above-mentioned pair of electrodes

were bonded by hot pressing to the opposite sides of a proton conductive polymer electrolyte membrane having an external size of 20 cm × 20 cm such that the catalyst layers were in contact with the electrolyte membrane, to fabricate an electrolyte membrane electrode assembly (MEA). The proton conductive polymer electrolyte membrane was a thin film of perfluorocarbon sulfonic acid having a thickness of 50 μm.

[0022]

Next, a conductive separator plate will be described.

First, 50 parts by weight of an artificial graphite powder having an average particle size of approximately 10 μm, 30 parts by weight of fibrous graphite having an average diameter of 50 μm and an average length of 0.5 mm, and 20 parts by weight of a thermosetting phenol resin were mixed and kneaded with each other by an extrusion kneading machine. The mixture powder was charged into a die having a pattern for forming a gas flow channel groove, a cooling water flow channel groove and manifold apertures and was hot pressed. The conditions of the hot pressing were: a die temperature of 150℃ and a pressure of 100 kgf/cm^2 for 10 minutes. The separator plate obtained had an external size of 20 cm × 20 cm and a thickness of 3.0 mm, and the gas flow channel and the cooling water flow channel had a width of 1.0 mm and a depth of 1.0 mm. The rib formed between the flow channels had a width of 1.0 mm.

The MEA sheet was sandwiched by an anode-side and cathode-side separator plates produced in the above manner, and was clamped such that the portion of the carbon nonwoven fabric contacting the rib had a thickness of 0.11 mm. In this way, a unit cell as illustrated in FIG. 3 was produced. The carbon nonwoven fabric of the electrode protruded into the gas flow channel, at maximum, by 0.25 mm.

[0023]

<<Example 2>>

In the same manner as in Example 1, a separator plate having an external size of 20 cm × 20 cm and a thickness of 3.0 mm was produced. The gas flow channel and the cooling water flow channel had a width of 2.0 mm, a depth of 2.0 mm, and a rib width of 0.5 mm. The MEA sheet was sandwiched by these two separator plates, and was clamped such that the portion of the carbon nonwoven fabric contacting the rib had a thickness of 0.11 mm. By this, the carbon nonwoven fabric protruded into the gas flow channel, at maximum, by 0.25 mm, and had a cross-sectional shape similar to that of FIG. 3.

[0024]

<<Example 3>>

An MEA was produced in the same manner as in Example 1 except for the use of carbon nonwoven fabric having an external size of 16 cm × 16 cm and a thickness of 0.21 mm (TGP-H-120 manufactured by Toray Industries, Inc.). Next, a separator plate having an external size of 20 cm × 20 cm and a

thickness of 3.0 mm was produced in the same manner as in Example 1. The gas flow channel and the cooling water flow channel had a width of 1.0 mm, a depth of 1.0 mm, and a rib width of 1.0 mm. The MEA sheet was sandwiched by these two separator plates, and was clamped such that the portion of the carbon nonwoven fabric contacting the rib had a thickness of 0.11 mm. By this, the carbon nonwoven fabric protruded into the gas flow channel, at maximum, by 0.10 mm, and had a cross-sectional shape similar to that of FIG. 3.

[0025]

<<Example 4>>

In the same manner as in Example 1, a separator plate having an external size of 20 cm × 20 cm and a thickness of 3.0 mm was produced. The gas flow channel and the cooling water flow channel had a width of 1.0 mm, a depth of 1.0 mm, and a rib width of 1.0 mm.

Next, a method of producing an electrode comprising a catalyst layer will be explained.

First, 25% by weight of platinum particles having an average particle size of approximately 30 Å were placed on an acetylene black powder. A dispersion of this catalyst powder in isopropanol was mixed with a dispersion of perfluorocarbon sulfonic acid powder in ethyl alcohol to form a catalyst paste.

Meanwhile, as the base material of a gas diffusion layer, polyacrylonitrile fibers having a diameter of approximately 10 μm and a length of approximately 5 mm were

dispersed in water and were made into a sheet. Subsequently, the sheet was impregnated with a phenol resin solution diluted to a concentration of 40% by weight with ethanol, and was dried at approximately 100℃ for 10 minutes to cure the resin. This was heated under a nitrogen atmosphere at 2000℃ for 24 hours for graphitization, which produced a carbon paper having a thickness of 0.2 mm. Thereafter, the carbon paper was immersed in a diluted solution which was a mixture of an aqueous dispersion of a water repellent (NEOFLON ND1 manufactured by Daikin Industries, Ltd.) and water in a weight ratio of 1:10, and was then dried at approximately 60℃ for 1 hour. Further, an aqueous dispersion of acetylene black and polytetrafluoroethylene (PTFE) in a weight ratio of 3:1 was prepared, and the aqueous dispersion was applied onto the carbon paper prepared in the above manner with a doctor blade to form a water repellent layer. This was dried at approximately 60℃ for 1 hour and baked at approximately 380℃ for 15 minutes. The carbon paper was cut such that its external size became 16 cm × 16 cm.

[0026]

The separator plate was placed on the carbon paper such that the carbon paper came in contact with the gas flow channel of the separator plate. Then, by the application of a pressure of 100 kgf/cm² per the contact area, the portion of the carbon paper contacting the rib of the separator plate was compressed to form the recess 33 having a depth of 0.1 mm as

illustrated in FIG. 4. The catalyst paste was applied by screen printing onto the other side of the carbon paper, i.e., on the surface having the water repellent layer, to form a catalyst layer. Then, the catalyst layer was partially embedded in the carbon nonwoven fabric. In this way, a pair of electrodes each comprising the catalyst layer and the carbon nonwoven fabric were prepared. In each of the electrodes, the content of platinum was 0.5 mg/cm^2, and the content of perfluorocarbon sulfonic acid was 1.2 mg/cm^2.

[0027]

Thereafter, the pair of electrodes were bonded by hot pressing to the opposite sides of a proton conductive polymer electrolyte membrane having an external size of 20 cm × 20 cm such that the catalyst layers were in contact with the electrolyte membrane, to fabricate an MEA. The same polymer electrolyte membrane as that of Example 1 was used. The MEA sheet was sandwiched by the above-mentioned two separator plates and was then clamped, to assemble a unit cell as illustrated in FIG. 5. The clamping pressure was 15 kgf/cm^2 per unit area. Therein, the compressed portions of the gas diffusion layers of the MEA aligned with the ribs of the separator plates.

[0028]

<<Comparative Example 1>>

First, in the same manner as in Example 1, a separator plate having an external size of 20 cm × 20 cm and a

thickness of 3.0 mm was produced. The gas flow channel and the cooling water flow channel had a width of 1.0 mm, a depth of 1.0 mm, and a rib width of 1.0 mm.

As the base material of the gas diffusion layer, the carbon paper of Example 4 before being pressed by the separator plate was used. This was cut into an external size of 16 cm × 16 cm. Thereafter, a catalyst layer was formed on the side having the water-repellent layer, using the same catalyst paste as that of Example 1. Then, the catalyst layer was partially embedded into the carbon nonwoven fabric.

In the same manner as in Example 1 except for the use of the separator plates and the electrodes thus produced, a unit cell as illustrated in FIG. 6 was assembled. In FIG. 6, 51 represents a polymer electrolyte membrane. Of an anode 52A and a cathode 52B sandwiching the polymer electrolyte membrane, the portions of the gas diffusion layers facing gas flow channels 54A and 54B of separator plates 53A and 53B have almost the same shape and properties as the other portions.

[0029]

<<Comparative Example 2>>

Also, the preparation of an MEA was made by the same method as that of Example 1.

In the same manner as in Example 1, a separator plate having an external size of 20 cm × 20 cm and a thickness of 3.0 mm was produced. The gas flow channel and the cooling water flow channel had a width of 0.5 mm, a depth of 1.0 mm,

and a rib width of 1.0 mm. The same MEA sheet as that of Example 1 was sandwiched by the above-mentioned two separator plates, and the resultant was clamped such that the portion of the carbon nonwoven fabric contacting the rib had a thickness of 0.11 mm. Then, since the width of the gas flow channel of the separator plate was narrow, the carbon nonwoven fabric was compressed as a whole, protruding only a little into the gas flow channel by not more than 0.05 mm, as illustrated in FIG. 7.

[0030]

<<Comparative Example 3>>

In the same manner as in Example 1, a separator plate having an external size of 20 cm × 20 cm and a thickness of 3.0 mm was produced. The gas flow channel and the cooling water flow channel had a width of 1.0 mm, a depth of 0.5 mm, and a rib width of 1.0 mm. The same MEA sheet as that of Example 1 was sandwiched by the above-mentioned two separator plates, and the resultant was clamped such that the portion of the carbon nonwoven fabric contacting the rib had a thickness of 0.11 mm. By this, the carbon nonwoven fabric protruded into the gas flow channel by 0.25 mm, and had a cross-sectional shape similar to that of FIG. 3.

[0031]

<<Comparative Example 4>>

Also, the preparation of an MEA was made by the same method as that of Example 1. In the same manner as in Example

1, a separator plate having an external size of 20 cm × 20 cm and a thickness of 3.0 mm was produced. The gas flow channel and the cooling water flow channel had a width of 1.0 mm, a depth of 1.0 mm, and a rib width of 2.0 mm. The same MEA sheet as that of Example 1 was sandwiched by the above-mentioned two separator plates, and the resultant was clamped such that the portion of the carbon nonwoven fabric contacting the rib had a thickness of 0.11 mm. By this, the carbon nonwoven fabric protruded into the gas flow channel by 0.25 mm, and had a cross-sectional shape similar to that of FIG. 3.

[0032]

Of each of the unit cells described in the above Examples 1 to 4 and Comparative Examples 1 to 4, 100 unit cells were stacked to form a cell stack. A stainless steel current collector plate and an electrically insulating plate were joined to each end of the cell stack, and the resultant stack was sandwiched between end plates. The end plates were then fixed with clamping rods. The clamping pressure was 15 kgf/cm^2 per area of the separator plate. A cooling section was provided every two cells of the cell stack. The cooling section was formed by a composite separator plate consisting of a separator plate having a cooling water flow channel on one side and a fuel gas flow channel on the other side and a separator plate having a cooling water flow channel on one side and an oxidant gas flow channel on the other side, these two separator plates being joined together such that their

cooling water flow channels faced each other. Except for this section, the separator plate inserted between the MEAs was a separator plate having a fuel gas flow channel on one side and an oxidant gas on the other side.

[0033]

Each of the polymer electrolyte fuel cells produced in the above manner was retained at 75℃, while a hydrogen gas humidified and heated to have a dew point of 75℃ and air humidified and heated to have a dew point of 75℃ were supplied to the anode and the cathode, respectively. As a result, all the cells exhibited an open-circuit cell voltage of 95 to 96 V at the time of no load when current was not output to outside. Each of these cells was subjected to a continuous power generation test under the conditions of a fuel utilization rate of 85%, an oxygen utilization rate of 50%, and a current density of 0.7 A/cm^2 to measure changes in output characteristics with passage of time. Table 1 shows average values of discharge characteristics, as hydrogen-air fuel cells, of the cell stacks of Examples 1 to 4 and Comparative Examples 1 to 14.

[0034]

[Table 1]

	Gas diffusion layer		Separator dimensions (mm)			Cell stack voltage (V)
	Kind	Protrusion (mm)	Gas flow path width	Depth	Rib width	
Example 1	Carbon nonwoven fabric	0.25	1.0	1.0	1.0	62
Example 2	Carbon nonwoven fabric	0.25	2.0	2.0	0.5	63
Example 3	Carbon nonwoven fabric	0.10	1.0	1.0	1.0	62
Example 4	Carbon paper	0.10	1.0	1.0	1.0	62
Comparative Example 1	Carbon paper	0.00	1.0	1.0	1.0	Unable to operate stably
Comparative Example 2	Carbon nonwoven fabric	~0.05	0.5	1.0	1.0	50
Comparative Example 3	Carbon nonwoven fabric	0.25	1.0	0.5	1.0	Unable to discharge
Comparative Example 4	Carbon nonwoven fabric	0.25	1.0	1.0	2.0	57

[0035]

As is apparent from Table 1, it was confirmed that in Examples 1 to 4, a cell voltage of approximately 62 V was maintained over 8000 hours or more.

The cell of Comparative Example 1 retained a cell output of approximately 12.8 kW (57V - 224A) for the first one to three hours of the continuous operation. However, after

the elapse of 1 to 3 hours, the cell voltage started to fluctuate, and the flooding phenomenon was observed due to overwetting of the cell. When a comparison was made of the pressure losses of the anode reaction gas and the cathode reaction gas between the Example 4 and the Comparative Example 1, the pressure loss of the Comparative Example 1 was lower by 30%. This decrease in pressure loss is the cause of the flooding phenomenon, and the cause of the decrease in pressure loss is an increase in the proportion of the underflow.

[0036]

In Comparative Example 2, a stable operation was observed, but the voltage of the cell stack was lower than those of Examples 1 to 4 by 12 V. In Comparative Example 2, the carbon nonwoven fabric was compressed as a whole. In contrast, in Examples 1 and 3, the carbon nonwoven fabric protruded toward the gas flow channel, so that it maintained the gas permeability close to that in an uncompressed state. This is considered to be the reason of the occurrence of such voltage difference.

In Comparative Example 3, the voltage dropped sharply at an early stage. When a comparison was made of the pressure loss of the cathode reaction gas at the time of no load between the Comparative Examples 2 and 3, the pressure losse of Comparative Example 3 was about three times that of Comparative Example 2. At such a high pressure loss level, it is beyond the capacity of the testing unit to supply the

reaction gas at a flow rate necessary for the oxygen utilization rate to become 50%. Therefore, the shortage of the reaction gas is the cause of failure of discharge.
[0037]

In Comparative Example 4, although a stable operation was observed, the voltage of the cell stack was lower than those of Examples 1 to 4 by 5 V. In Examples 1 to 4 and Comparative Examples 2 and 4, since the portion of the gas diffusion layer contacting the rib was compressed, the proportion of the underflow was reduced. Thus, at the catalyst layer under the rib, the shortage of the supplied reaction gas promoted reaction polarization. In Comparative Example 4, the rib width was greater than that of Example 1, so the reaction polarization was promoted at larger area, resulting in a decrease in voltage as described above.

As described above, by causing the gas diffusion layer of the MEA to protrude into the gas flow channel of the separator plate and causing the gas flow channel to have appropriate dimensions, it is possible to suppress the flooding in the electrode while retaining good gas diffusibility and steam permeability, and to provide an electrode and a fuel cell having high discharge performance and reliability.
[0038]

[Effects of the Invention]

As described above, the present invention makes it

possible to evenly supply the reaction gas to the catalyst of
the catalyst layer and promptly discharge excessive water
generated therein, by optimizing the gas diffusion layer and
the dimensions of the gas flow channel. Therefore, it is
possible to realize a fuel cell having high discharge
performance and reliability.

[BRIEF EXPLANATION OF THE DRAWINGS]

[FIG.1]

A sectional view of the main part of a unit cell of
a conventional polymer electrolyte fuel cell.

[FIG. 2]

A front view of a separator plate showing an
underflow of a reaction gas.

[FIG. 3]

A sectional view of the main part of a unit cell in
one example of the present invention.

[FIG. 4]

A partially sectional view of a gas diffusion layer
in another example of the present invention.

[FIG. 5]

A sectional view of the main part of a unit cell
comprising the same gas diffusion layer of FIG. 4.

[FIG. 6]

A sectional view of the main part of a unit cell in
Comparative Example 1.

[FIG. 7]

A sectional view of the main part of a unit cell in Comparative Example 2.

[Explanation of Reference Numerals]

1	Polymer electrolyte membrane
2A, 2B	Catalyst layer
3A, 3B	Gas diffusion layer
4A, 4B	Separator plate
5A, 5B	Gas flow channel
6A, 6B	Rib
10a, 10b	Fuel gas manifold aperture
14	Separator plate
15	Gas flow channel
17	Underflow
21	Polymer electrolyte membrane
22A, 22B	Protruded part of gas diffusion layer
23A, 23B	Compressed part of gas diffusion layer
24A, 24B	Separator plate
25A, 25B	Gas flow channel

【書類名】　　　　　　図面　[DOCUMENT NAME]　　Drawings
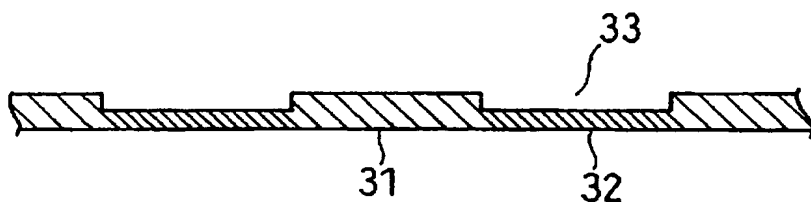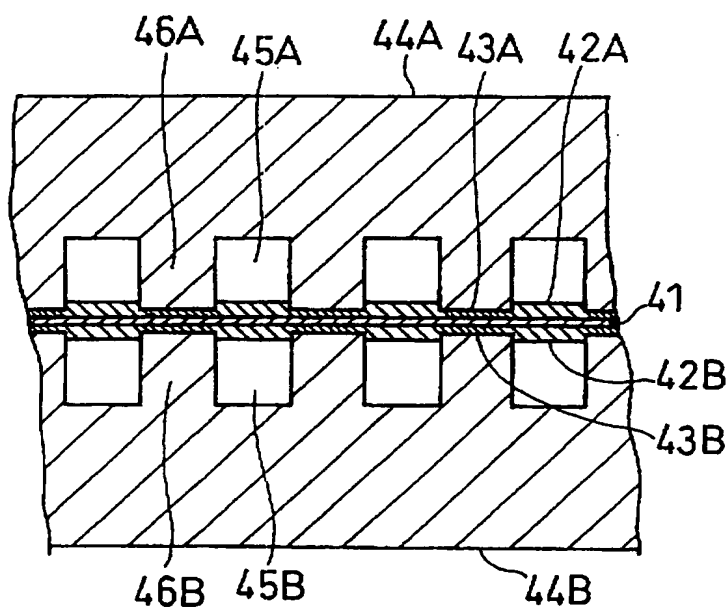
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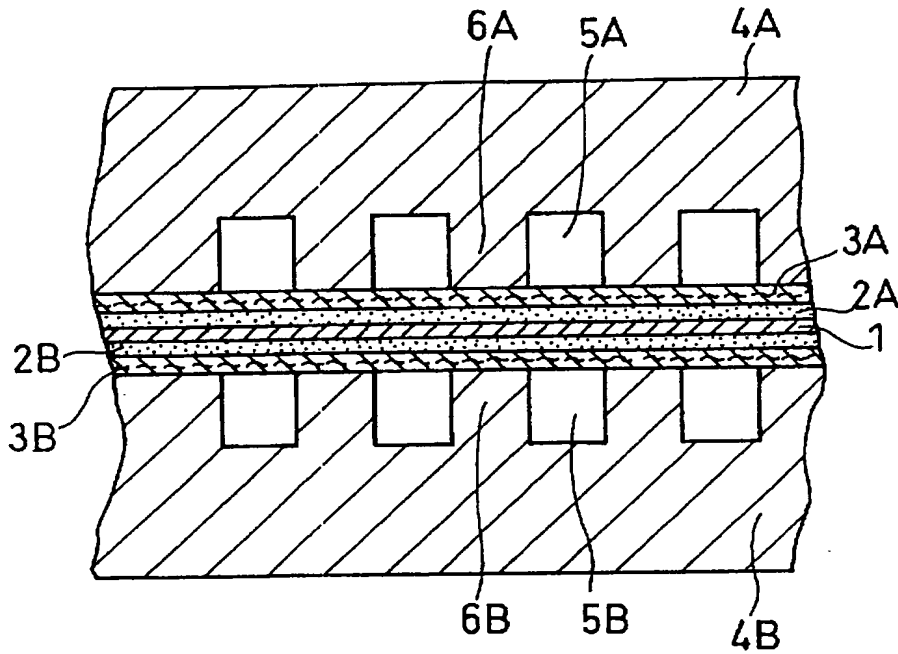
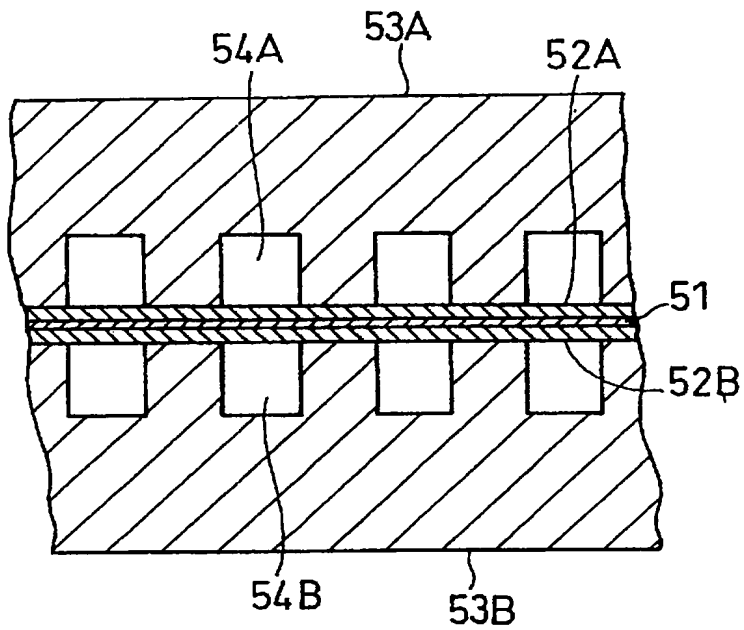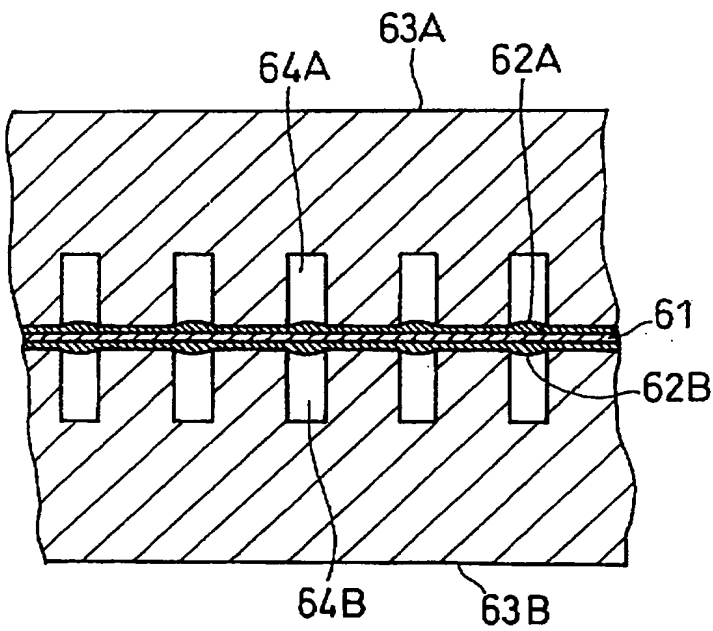【図２】　[FIG. 2]
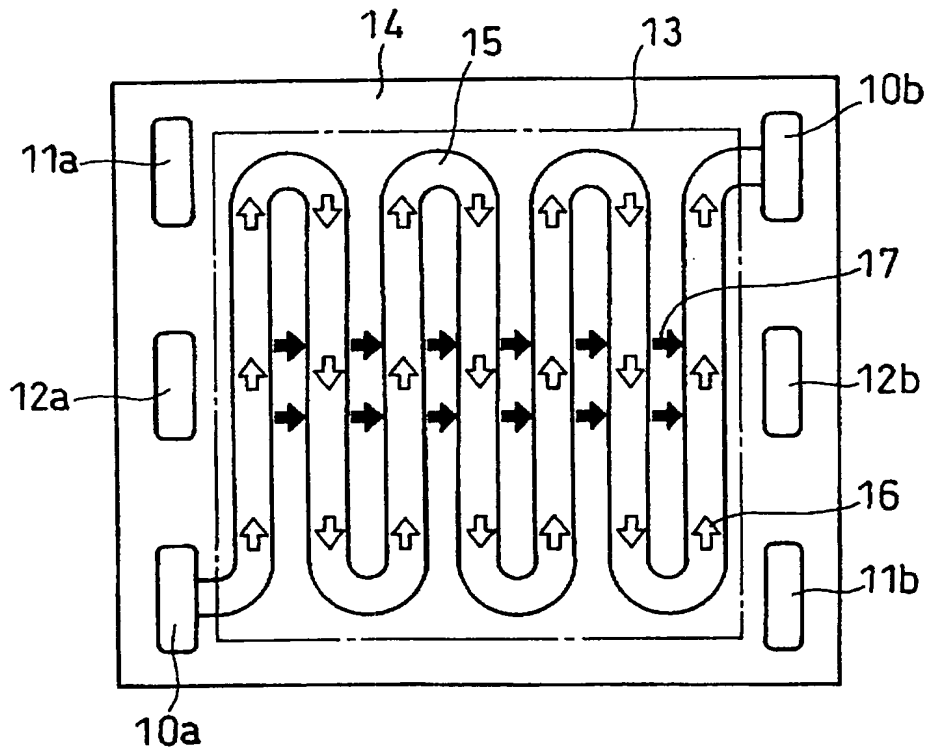
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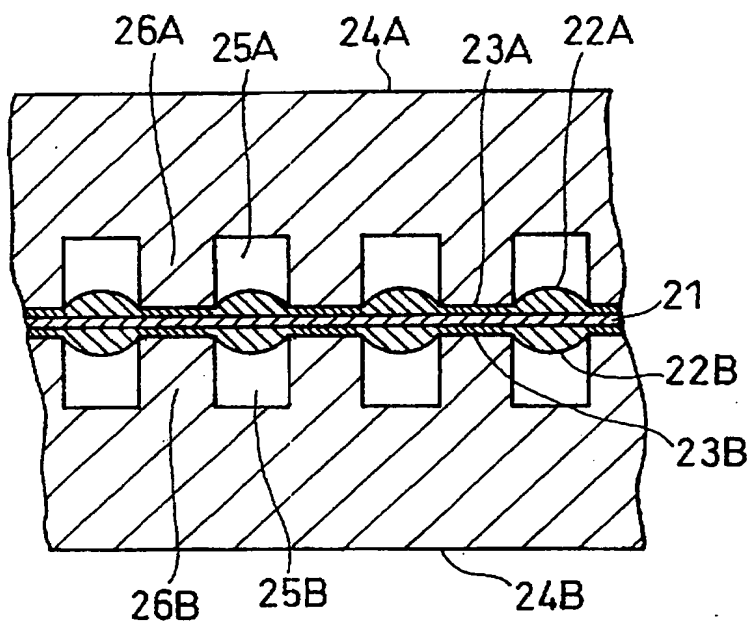
【図4】　[FIG. 4]

【図5】　[FIG. 5]

【図6】　[FIG. 6]

【図7】　[FIG. 7]

2002-230538

(Translation)

[DOCUMENT NAME] Abstract

[ABSTRACT]

[OBJECTIVE] To provide a fuel cell that is capable of evenly
supplying a reaction gas to the catalyst of a catalyst layer
and promptly discharging excessive water generated therein,
and that has high discharge performance and reliability, by
optimizing the shape and properties of a gas diffusion layer
and the dimensions of a gas flow channel.

[SOLVING MEANS] The gas diffusion layer of an MEA protrudes
into the gas flow channel of a separator plate. Also, the gas
flow channel of the separator plate has sufficient width and
depth for the protrusion of the gas diffusion layer, and the
width of the rib formed between the gas flow channels is made
narrow.

[SELECTED DRAWING] FIG. 3